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QUARTERMASTER RESEARCH & ENGINEERING COMMAND
U S ARMY

TECHNICAL REPORT
EP-60

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EFFECTIVENESS OF PROTOTYPE COLD WEATHER FACE MASKS FOR MILITARY ACTIVITIES

QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

JUNE 1957

NATICK, MASSACHUSETTS

HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
OFFICE OF THE COMMANDING GENERAL
NATICK, MASSACHUSETTS

Major General Andrew T. McNamara
The Quartermaster General
Washington 25, D. C.

Dear General McNamara:

This report, "Effectiveness of Prototype Cold Weather Face Masks for Military Activities," describes the experiences of various Army personnel (Corps of Engineers, Ordnance, and Quartermaster Arctic Test Team personnel, Armor personnel and foot soldiers in Arctic bivouac) with the best available cold weather face masks, while performing a variety of duties. In addition, the report summarizes previous Quartermaster Corps efforts to develop devices for protecting the face against cold, wind, blowing snow, cold rain, spray, and — under conditions of high windchill — against frostbite.

The report is primarily for designers and developers of cold weather face protective devices. The report should also be a useful guide to individuals who are responsible for the protection of the soldier in cold climates.

Sincerely yours,

C G Calloway
C. G. CALLOWAY
Brigadier General, USA
Commanding

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EP-60

HEADQUARTERS QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

Technical Report
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EFFECTIVENESS OF PROTOTYPE COLD WEATHER FACE MASKS FOR MILITARY ACTIVITIES

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FOREWORD

One of the important responsibilities of the Quartermaster Corps is to furnish the Army with clothing and personal equipment which will protect the individual soldier and make it possible for him to function effectively during extremely cold weather. In order to meet this responsibility, the Quartermaster Research and Engineering Command is conducting research to discover principles of protection against the cold, and research and development relating to cold weather clothing and personal equipment.

Development of protective clothing and equipment for use under conditions of high windchill is particularly important, especially when circumstances make it necessary for troops to face directly into the wind. Under such extreme conditions, the ability of troops to keep their faces from freezing is a critical limiting factor which plays an important part in determining troop effectiveness.

This report evaluates the need for cold weather face protective devices, and surveys past Quartermaster research and development in this area. It also describes and draws conclusions concerning men's experiences with and reactions to the prototype masks studied, and makes recommendations concerning desirable future development of devices for protecting the face against high windchill conditions.

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ABSTRACT

Quartermaster research on protection of the face against cold and wind was surveyed, and the use of two new face masks ("Coldbar" and "Wood-Hafferty") by men engaged in a variety of military activities under severe conditions of windchill was studied. Information was secured concerning the need for face protection, military requirements for face masks, desirable and undesirable characteristics of masks studied, their effectiveness under various conditions, and improvements needed. The Wood-Hafferty mask, despite flaws in design, construction, and performance is highly acceptable to operators of open engineering equipment, tank commanders, telephone linemen, and men preparing for demolition work; it markedly increases their effectiveness under severe conditions of windchill. The Coldbar Arctic Face Mask is preferred by gunners who are very active physically while testing ammunition. Both masks materially increased the effectiveness and comfort of their wearers.

EFFECTIVENESS OF PROTOTYPE COLD WEATHER FACE MASKS FOR MILITARY ACTIVITIES

Part I - Requirements for Face Protection and Items Developed

1. Requirements for Face and Eye Protection in the Arctic

a. The Eskimo

The occasion of the first realization by the Eskimo of the need for face protection is lost in antiquity, but his excellent solution for this problem, the parka hood with a wolverine fur ruff, was long considered by many experts to be the best available method of protecting the face against Arctic winds, cold and blowing snow. However, the parka hood and ruff do not completely protect the face under extremely severe conditions, and frostbite of the face is by no means unknown among Eskimos or Arctic explorers. For example, Stefansson (39, pp. 75, 76) reports that Natkusiak, one of the best of the Eskimo members of his expedition, frequently froze his face; Stefansson also reports frequent frostbite of the chin, cheek, and nose among other members of his expedition. Stefansson tends to make light of frostbite of the face, stating that ". . .a frozen cheek or nose is no more serious than a sunburn, if you thaw it out with your warm hand promptly as soon as it begins to freeze."

Freezing of the face is usually superficial, i.e., only skin deep (1, p. 2). However, this should not lead one to ignore the seriousness of severe frostbite - particularly deep frostbite of the extremities - as was convincingly demonstrated in Korea (19). On the other hand, since the face was involved in only a fraction of one percent of frostbite cases in Korea, it appears that the face protective gear available was adequate for the weather conditions which existed there. However, this tells us nothing concerning the adequacy of such equipment under conditions of more extreme windchill.

b. U. S. Military Personnel

The need for protecting the face from cold, wind, blowing snow, cold rain, and spray has been recognized in official Army, Navy, and Air Force publications (41-44, 55). There is a military requirement for hoods, shields or masks which will protect the face from frostbite, but the protective gear must permit normal speech, hearing, vision (including an angle of vision of 180°), permit turning the head freely through an angle of approximately 180° without simultaneously turning the body, and it must be compatible for wear with head armor, gas masks, and spectacles. It must also permit the individual to operate under normal tactical conditions, including parachute operations, without unduly limiting efficiency. However, one report (47) emphasizes the reluctance of men to wear face masks, and recommends that the need for and desirability of a mask be reconsidered. These points merit further study, and are considered in the present investigation.

c. Operating Tractors and Bulldozers

As aircraft were introduced into the Arctic, and as bulldozers and other heavy mechanical equipment were brought in to clear snow from roads and airstrips, problems of face protection developed which were more severe than had previously existed. The operator of a large caterpillar tractor has requirements for face protection which are different from, and in many respects greater than, those of the Eskimo or the Arctic explorer proceeding on foot or following his dog team. He sits six or eight feet above the ground, with absolutely no protection against the wind except his clothing, constantly harassed by wind blowing into his face loose snow and snow churned up by his equipment. He must use both hands to control his equipment, and hence can use his hands only a small portion of the time to protect or warm his face. He cannot close his parka hood too completely because of the need to see both ahead and to the side in order to avoid hitting obstacles or personnel and to do his work properly. He must keep this up several hours at a stretch, day after day, during the windiest and coldest weather. Under these conditions (34, p. 1) the length of time a well-clothed man can work effectively in an exposed position is governed mainly by the ability of his face to endure the cold, wind, and blowing snow. Men with extensive Arctic experience agree that at windchills greater than 1,400 Kg Cal/m^2/hr, at which exposed flesh freezes (36, p. 423), there is need for some degree of face protection; at higher windchills the need is increased; and at windchills above 2,000, considerable protection is necessary.

d. Blizzard Conditions

Under extremely severe conditions, such as the blizzard conditions which were experienced by the French Polar Expedition to Adelie Land in the Antarctic from 1948 to 1951 (33), the problem of vision becomes extremely acute because of ice formation on faces and masks, especially around the eyes. If conditions of windchill are so severe that dogs will not face the wind, Arctic experts (38, p. 332) advise against attempting to travel. However, a military situation might demand that men travel under these conditions, or to do so might give a definite advantage to the side which has equipment, including masks which both adequately protect the face and furnish good vision, for making such travel feasible.

2. Development of Face Protective Devices

a. Eskimo Parka Hood with Fur Ruff

The Eskimo parka hood with a fur ruff is known to give reliable protection under all but the most severe windchill conditions, and most individuals who have experienced cold-dry conditions understand how to use it. It has been used in modified form by the U. S. Army (52) (Figure 5)*, Navy (Figure 6) (51), and Air Force. Its main limitations for military

* Figures 1 - 4 are in Part II; all other figures are in Appendix A.

purposes are: 1) it was not designed for combat use, 2) the hood and ruff, when nearly closed, serious limit the field of vision, 3) adequate natural materials are expensive, and 4) natural materials are not available in sufficient quantities (18, Appendix B, p. 3) to equip an army. However, much progress is being made toward the development of synthetic fur materials for ruffs.*

b. Air-permeable Face Masks in Direct Contact with the Skin

The Army entered World War II equipped with headwear and face protection items left over from World War I. The only device for face protection was a toque similar to the British balaclava. It was a knitted wool tube, closed at one end, with an opening for the eyes, and made sufficiently form-fitting to be worn under headgear. The Toque, wool, knit, M-1941 (Figures 7 and 8), basically a revival of the World War I item, was reclassified limited standard in 1943, largely because of its lack of windproofness and the fact that it collected moisture from the breath. Under conditions of high wind-chill, these two factors make hazardous the wearing of any highly air permeable mask, because the wearer has ice in contact with his skin and little or no protection against the wind. Even when worn with a hood and ruff the item is a hazard, since frost and ice cannot be readily removed from it.

c. Air-impermeable Face Masks in Direct Contact with the Skin (Including Coldbar)

In an attempt to overcome the deficiencies of air-permeable masks, new masks were made of less air-permeable materials. A felt mask protected against cold, driving rain, spray, and wet snow (41) (Figure 9). The mask, field chamois (Figure 10), was quite windproof but easily became wet, and frost formed under it next to the skin. Other masks were: a mask made of reclaimed rubber and cotton (E-654.3); a Navy mask (651) (Figure 11), consisting of two thin layers of cloth covered with an olive drab windproof material similar to oilcloth; an alpaca-mohair pile-lined poplin-covered mask (Mask, Field, Pile, Type I); and a Mask, Field, Pile, Experimental, Double-faced Wool (Figure 12). The last two were designed to avoid defects apparent in the other masks. A test resulted in unanimous agreement that the double-faced wool pile was superior to wool felt as lining material (11, p. 13). The double-faced wool pile previously had been found (5, p. 2) to be warmer than the alpaca-mohair pile material. Changes (11, pp. 19, 20) were made to improve the fit of the double-faced wool pile mask and to provide a greater area for protection. More fundamental changes consisted in stiffening the nose guard and adding pile padding around the nose and eyes (9, 11, p. 20) to prevent expired air from escaping about the eyes** and to

*See "Development of non-critical substitutes for wolverine fur," TS-92, Textile, Clothing and Footwear Division, Quartermaster R&D Command, Natick, Mass., September 1956; for a report on these studies.

**It should be noted that the Mask, Face, Cold Weather, incorporated, but did not carry out successfully, the fundamentally sound principle discussed in the next section, of a seal to prevent expired air from escaping about the eyes.

hold away from the nose and mouth any fabric which condensed moisture. In addition, the eye and mouth openings were enlarged and a relatively stiff mouth guard, which could be elevated, was provided. This mask was found superior to the other masks in the laboratory and preliminary field tests (11, p. 5), but was considered unsatisfactory during Task Forces FROST, FRIGID, and WILLIWAW of the winter 1946-47 because it became wet easily, impaired visibility, collected frost, was difficult to dry, and was rarely worn by choice (15, 37, 45, 46). It was declared limited standard* and was replaced by the Mask, cheek protector (Figure 13), a very simple and inexpensive item designed to shield the nose and cheeks (53) from cold wind. Two cheek protector masks were to be carried by each man, one to be worn while the other was being dried inside the clothing. During 1949 the Quartermaster Board (47) criticized this mask, and Army Field Forces Board No. 3 (43, p. 3) found it unsuitable for Army Field Forces use because, after a short period of wear, moisture from the breath condensed between the mask and skin, causing skin irritation, fogging of glasses, and in some cases, frostbite. (In spite of these defects, this item remains in supply channels (53).)

Only masks which are both non-fogging and transparent have the advantage of allowing the effective operation of the "buddy system" of inspecting for frost patches forming on the skin. Unless men are experienced in detecting the first signs of frostbite by movements of their facial muscles, it is likely that more cases of frostbite of the face may occur when opaque masks are worn than when no masks are worn.

From 1953 to 1956 the Quartermaster R&D laboratories developed several models of the "Coldbar" mask (Figures 3 and 4) from a unicellular plastic foam material, polyvinyl chloride — Buna N blend (Ensolite) which is an excellent insulator, is wind- and water-impermeable, and feels warm against the skin. However, this mask shares some, but by no means all, of the disadvantages common to opaque masks which are in direct contact with the skin of the face.

Two or three years ago, the Canadian Army developed a somewhat similar mask of other materials, which were found to be insufficiently durable for field use. As a result, it was modified by adding a stiff, form-molding layer. In 1957 the Canadian mask was compared (32) with the Wood-Hafferty mask (Figures 1 and 2), the "Coldbar" mask (Figures 3 and 4), and the standard cold-dry headgear (Figure 5), in terms of their potential in maintaining facial skin temperatures under high windchills. It was found that skin temperatures were lower for the Canadian than for the other masks.

d. Face Masks with Airtight Compartment Around Mouth and Nose

Several investigators (9, 20, 57, 58) have independently developed face masks with separate airtight compartments around the mouth and nose, sealed off from the rest of the face. A similar principle has been used in

*A mask, Cold Weather, Type D-1A, designed somewhat similarly, but made out of felt, is currently available as a standard item (54).

gas masks. This is a basic improvement over masks previously used, which admitted expired air into the space between the eye and goggle, causing rapid frosting at low temperatures.

e. Face Shields

Between 1947 and 1950, Army Engineers(3,34,40) developed an Arctic Face Shield (Figure 17) designed for operators of bulldozers and other heavy equipment which do not provide protection from the cold and wind. The shield, made of 1/16-inch thick transparent plastic (lucite) is suspended from a hard fibre headgear designed to hold a welder's mask. There is a main shield with a cutout at the bottom, behind which a frost apron is mounted at a slight angle. The apron which extends from the bottom of the main shield to a point just above the tip of the wearer's nose, is designed to catch moisture from the nose and mouth. The cutout in the main shield allows the wind to strike the sloping frost apron and be deflected upward behind the main shield and out of the open top of the device. The shield successfully protects the face from frontal winds and blowing snow without becoming frosted, and makes it easier for equipment drivers to perform their duties. It was not designed to keep the face warm, warm the air breathed, furnish side protection, or to be of general use in the Arctic.

In 1950, the Quartermaster Corps, through its contract with the Polaroid Corporation (30, p. 7), attempted to develop simple face-protective devices by combining the Engineer's Face Shield with a Quartermaster modification of a heat-regenerating mask (4) consisting of a flanged rubber oro-nasal device with a projecting carrier containing bronze wool to conserve heat otherwise lost in exhaled breath. The resulting devices either frosted up from lack of ventilation or permitted drafts of cold air to strike the cheeks, eyes, and sides of the head. The devices were unsatisfactory in laboratory tests, and work on them was discontinued in order to concentrate on the development of the Toque, Respirator, which is described in paragraph h below.

f. Goggles, Sunglasses, and Other Forms of Eye Protection

Stefansson (39, p. 239) describes Eskimo slit-type sunglasses, made of pieces of wood with two narrow slits for the eyes, each slit being about the size that would permit a half dollar to slip through. They protect the eyes from snow-blindness and do not cloud over. However, they restrict the field of vision. Through the narrow slits the wearer can see what is in front of his feet only by lowering his head. As a result, on rough ice or uneven ground he continually stubs his toes against obstacles.

A detailed discussion of various types, colors, shapes, and materials used in the construction of goggles would be lengthy and largely irrelevant to our purposes, and will not be included. However, attempts to keep glasses and goggles from "frosting up" at low temperatures will be described, because this is the commonest type of failure of face-protective devices and the most difficult to overcome.

Chemically-treated lenses have been tried, including commercially available fluids used to prevent frosting of eyeglasses. They have some favorable effect, but are not adequate under severe conditions. During

1944 and 1945 the Quartermaster Corps attempted to develop moisture-absorbing films suitable for use in goggles. Gelatin-coated lenses had "excellent anti-fog properties" (10, p. 1), but after absorbing water, the surface became so soft (10, p. 2) that even the most careful wiping completely destroyed optical properties of the lens, and at low temperatures, crystallization of water in the films destroyed their transparency. Attempts to harden gelatin were unsuccessful. Also, cellophane, cellophane laminations, and regenerated cellulose sheets were studied (6, p. 4) and various chemical treatments tried with each, but none were satisfactory (6, p. 10).

Double and triple lenses with sealed-in air spaces (sometimes including drying chemicals to prevent condensation between lenses) are widely applied to prevent frosting of windows and windshields, and have been used in goggles, face masks, and winterizing kits for gas masks. The principle is sound, but by itself is usually insufficient to prevent fogging or frosting of eye pieces under severe conditions. Several investigators have attempted to prevent fogging and frosting by attaching metal fins to goggles, so that the moisture condenses on the metal rather than on the lenses (7, 8, 14, 21, 33). Goggles with condensers of various forms and with both double lenses and incomplete inner lenses have been tried (7, 8, 14, 33). However, condenser goggles proved unsatisfactory for mountain climbing (49), even under moderate conditions, because they were easily damaged and interfered with efficient use of headgear. Other condenser goggles failed to function under severe blizzard conditions (33, p. 48-50).

Many types of ventilated goggles have been designed and tested. Ventilation reduces, but ordinarily will not prevent fogging unless the exhaled breath is kept away from the goggle surfaces. Even when metal or plastic screen eye-pieces have been used, difficulties occur, such as were observed with the Coldbar mask in a Climatic Chamber study (32) and in the present study.

Goggles with partially or completely open fronts (Figures 16 and 18) have been tried for protection against the wind and to prevent excessive tear formation (Cowan (13) and Price (31)) for shipboard use, and by Sapin-Jaloustre (33) for use under extreme blizzard conditions. Cowan found them useful for look-outs on shipboard, but Price found that they had numerous and pronounced shortcomings at 0° F to 35° F temperatures and in winds up to 40 knots. Sapin-Jaloustre tested them under severe blizzard conditions and found that they greatly reduced the field of vision and could not be used by men wearing eye-glasses because the latter frosted.

Shanty (35) made a thorough theoretical study of thermodynamic factors in lens fogging in protective masks (see also Christensen 4, p. 9-13)) and concluded that (35, p. 21) ". . .lens fogging may be prevented in respirators for temperate use without the aid of Tissot deflectors or nosecup. . ." and that through proper design a simplified respirator ". . .can be made effective down to a range of temperature between -15° F and -30° F by utilization of available heat energy. . ." However, no practical mask has yet been designed which comes up to Shanty's theoretical expectations.

Electrically-heated goggles will not be discussed. While satisfactory goggles of this type exist, the necessary source of electric current is ordinarily not available in the situations in which goggles are most needed by Army personnel.

g. Heat-regenerating Respirator Devices

Preliminary work on heat-regenerating respirator units for face masks was carried out by the Quartermaster Corps in 1943-44 (4, 12) based on the belief that conservation of body heat and the prevention of severe damage to the lungs by inhalation of very cold air were important in the Arctic. It has long been recognized that, at low temperatures, heat is lost along with expired air, and it has been estimated (4, p. 8) that ". . . at minus 40° F a person with a tidal volume of 500 cc and a respiratory rate of 15 per minute may lose as much as 480 Calories over a period of 24 hours."

Basically the Heat-Regenerating Respirator consisted of a metallic element through which the individual breathes. Expired air warmed the element by simple transfer of heat and by condensation of moisture from the air. Inspired air was moistened and warmed as it passed over the respirator element. The necessary heat was derived from the cooling of the inspired air plus heat released by the resulting condensation of moisture.

Results of tests at low ambient temperatures showed: 1) A majority of test subjects preferred to use a respirator unit rather than do without it, 2) Tolerance times with and without the respirator did not differ to a statistically significant degree, and 3) Vigorous exercise may be maintained longer when a respirator is used than when it is not used. In addition, steel wool and copper wool elements proved to be the best, and stainless steel was recommended (4, p. 16). Four respirators were field tested during Task Force FRIGID in 1946-47 (37, p. 41) at temperatures of -40° F or lower. They permitted comfortable breathing during the most strenuous activity at low temperatures, but the metal filings in the respirator became iced and ineffective after a short period of use. The icing was difficult to remove and the filings had to be changed frequently. Another difficulty was excessive condensation in the mouthpiece, which was annoying and also made the respirator unsatisfactory for wear while sleeping. In addition, the respirators were uncomfortable to wear, did not fit well, and leaked moist air which frosted the face mask and obstructed vision. The test results renewed some observers' belief in the need for a heat-regenerating respirator for troops engaged in strenuous physical activity at temperatures of -40° F or lower. They accordingly recommended (37, p. 41) that a study be conducted to determine what injury occurs in the respiratory system of the human during heavy breathing at temperatures below -40 F, and that a project be initiated to develop a heat-regenerating respirator that is effective and comfortable to wear at extremely low temperatures.

The Quartermaster Corps continued to work on the heat-regenerating principle, under contract with the Polaroid Corporation to develop a "Low Temperature Face Protective Device" (22-26). Near the beginning of this

contract a planning conference was held (1, p. 1; 22, Appendix I, pp. 1-3) in which it was estimated that at -65° F, 20% of the total body heat loss occurs through the lungs, and that almost half of this (i.e., about 10% of total body heat loss) could be saved through the use of a respirator. However, it was agreed that it had not been conclusively determined whether or not extremely cold air does actual lung damage.

During the remainder of 1948 and early 1949, important innovations were: the use of air entering the respirator to ventilate the goggles (22), the design, construction (23) and modification (24) of a mechanical breathing device, cold room tests of the heat regenerative device (24), and improvement (25) and field tests (26) of a combination head and face gear and respirator.

In 1949 the Quartermaster Corps concluded (26, pp. 8-11) that the small loss of body heat (10%) and lack of evidence for damage to the respiratory apparatus resulting from breathing cold air did not warrant the design complications introduced by heat-regenerating devices*. From this point on, heat regeneration was de-emphasized (27) and simplicity, better vision, and reduced bulk, reduced weight, and avoiding a feeling of confinement were stressed (28, 29). Several models of a new highly simplified device without the heat regenerator (Figure 15) were developed (27) during the second quarter of 1949, but did not perform satisfactorily. It was decided that the eyes must be enclosed in a relatively small space so that each inspiration would move sufficient air across the inner surface of the transparent eye-piece to keep it clear. In such forced-ventilation devices the seal between the eye area and the oro-nasal cavity must be perfect and must accommodate different individuals. For this reason the goggles and mask were combined in a single unit.

h. Toque, Respirator

During 1949 a "satisfactory head protective device" was developed (28), modified (29), and tested in the Climatic Chamber at Lawrence, Mass. Twelve Toques, respirator (EX 49-2) were supplied for further testing in the Chambers and during field trials at Fort Churchill during the winter of 1949-50. Results showed that the device provides the desired face protection and offers little resistance to breathing, but seriously impairs vision and transmission of speech. Minor deficiencies in design made impossible a thorough test of the principles incorporated in the device, but it was thought that many of these deficiencies could be overcome by simple modifications.

*Brebbia, D. R., R. F. Goldman and E. R. Buskirk of the Physiology Branch, Environmental Protection Research Division, QM R&E Center Laboratories, Natick, Mass., in a paper entitled WATER VAPOR LOSS FROM THE RESPIRATORY TRACT DURING OUTDOOR EXERCISE IN THE COLD, EP-57, May 1957, determined experimentally the heat loss from water vapor contained in oral expired air, and concluded that it was about 9% of the total energy expenditure, that it was directly proportional to ventilation volume, and that an average of 32 milligrams of water was collected from each liter of expired air.

In 1950, there was a concerted Quartermaster effort (30) to redesign the Toque, Respirator (EX 49-2). The fit of the Air Force A-13 "large" size oxygen mask was copied and the system of valved air passages used in the preceeding model was employed, but the frontal bosses of the A-13 design were eliminated to minimize protrusion and bulk. The goggle system and frontal design were modified to provide better vision down in front and to the sides, and the mask was made more flexible to facilitate aiming and firing a rifle (Figure 19). Toque, Respirator EX 50-3 (Figures 20 and 21) included a speech diaphragm, and Toque, Respirator, EX 50-4 (Figure 22) did not (30, p. 11). The best low-temperature plastic available at the time was used for eye pieces, but its optical properties were not entirely satisfactory (30, pp. 12, 13). A polarizing glare lens and an OD carrying case were furnished. The new respirators were worn with the Arctic Parka EX- 49-4, and tested between -40° F and -50° F, using the treadmill, and field tested during the winter of 1950-51. They were greatly desired by men whose duties required long hours of exposure to low temperatures and high winds, but the speech diaphragm in Toque, Respirator, EX 50-3, proved to be unnecessary.

The Toque, Respirator, EX 51-5, was based on Toque, Respirator, EX 50-4, with minor modifications, and was field tested (48) during 1952 at Mount Washington and at Fort Churchill, Canada. It adequately protected the head and face during exposure to low temperatures and high winds, and was highly desired by men exposed to such conditions. A number of Toque, Respirator, EX 51-5, Masks were shipped to the Continental Army Command, Arctic Test Branch in Alaska for winter testing, with the following results: The Arctic Test Branch concluded that the Toque, Respirator, is not suitable for CONARC use in the Arctic because the item fails to satisfy the requirements for climatic protection which does not adversely affect operational efficiency (42, p. 3). CONARC Board 3 (44) concurred in the preceding conclusion but modified an Arctic Test Branch recommendation to read ". . .that development be continued to provide suitable cold weather head, face, and neck protection under cold weather conditions." In order to prevent misinterpretation, it should be pointed out that the statement (42, Appendix A) to the effect that Arctic Test Branch would not request modification of the Toque, Respirator ". . . was based on the assumption that the modifications recommended as a result of the test would be so extensive as to constitute redesign," and does not necessarily mean ATB dissatisfaction with the basic principles of the Toque, Respirator. After CONARC recommended that no further consideration be given the Toque, Respirator, work was discontinued, the scientist monitoring the research left the Government service, and the considerable progress made has never been followed up.

i. The Wood-Hafferty Cold Weather Face Mask (Figures 1 and 2)

From the time that work on the Toque, Respirator, was discontinued, until 1954, there was little Quartermaster activity relating to face mask development, except work on the Coldbar mask and the mask described in paragraph k below.

In 1954, models of a patented face mask (58) were brought to the Quartermaster laboratories for study to determine its suitability for Army use. This mask combines an air-tight compartment around the nose and mouth, sealed off from the rest of the face, with a well-ventilated double layer transparent face piece which permits a wide field of vision and is held away from the face by a soft sponge plastic rim. In addition, it incorporates a simple partial heat-regenerating feature. Exhaled air passes over baffles in a relatively small rubber chamber and inhaled air follows the same path in the opposite direction. It is probable that the inhaled air picks up warmth and moisture from the baffles, since wearers report that air inhaled through the mask seems warmer and more moist than outside air. However, temperature and humidity differences between outside air and air inhaled through the mask have not yet been measured. Human engineering studies (16) were carried out in the Quartermaster Climatic Chambers, and the results were sufficiently favorable so that 26 prototype masks were constructed for use in the present and other studies.

j. Development of Arctic Gas Masks

The development of Arctic gas masks is more important in the history of face protection against cold than the brevity of the following discussion would indicate. Beginning in World War I, the U. S. Army Chemical Corps carried out research and development leading to the present standard mask, a winterizing kit, and various experimental and special purpose masks. An experimental Chemical Corps Arctic gas mask (Figure 14), which is of special interest because it employs a positive pressure system to ventilate the goggle lenses, was studied by Quartermaster technologists in 1950 (30). In it, exhaled, dehumidified air was vented into the double-lensed goggle cavity, rather than inhaled air being drawn through the goggle cavity. The unique feature and advantage of this type of ventilation is that the rubber face mask component had only to be airtight around the nose and mouth and not around the forehead and on the cheekbones, as is required by negative pressure devices utilizing inspired air to flush the goggle. The mask gave fog-free vision. However, the fabric became very stiff in the extreme cold, making it difficult to put on and take off, and the frontal frost bag ballooned up and impeded vision everywhere below the eye level.

The Canadian Army also has developed an experimental Arctic gas mask which has a larger field of vision and better binocular vision than most standard masks, especially for reading and "close work."

k. Complete Protection of Head Against Cold, Wind, CBR Agents, etc.

During 1953 and 1954, under Quartermaster contract, an attempt was made (2) to solve the problem of complete protection of the head against cold, wind, CBR agents, and fragmentation, but little progress was made on this complex problem, and no new principles or techniques resulted from the study.

Part II - Effectiveness of Wood-Hafferty and Coldbar Masks

3. Purpose of Study

The goal of this study was to secure information concerning the effectiveness and acceptability to the wearer of various design features of prototype cold weather face masks in relation to the activities of the wearer, as a basis for improving mask design and utilization. The purpose was neither to compare the available masks nor to select the best one; rather, it was to secure information concerning the advantages and disadvantages for use by men engaged in various activities, of each design feature of the masks. To an even greater extent the purpose was to develop hypotheses concerning desirable design characteristics and construction features, as a partial basis for future mask design. The above survey contributed directly to these purposes (Part I).

4. Method

A number of copies of a prototype Wood-Hafferty mask (Figures 1 and 2), made available by the Human Engineering Section, and a number of copies of a prototype Coldbar Arctic Face Mask (Figures 3 and 4) made available by the Plastics Section, Chemicals and Plastics Division, Quartermaster Research & Development Command laboratories, were studied during January and February 1956. Arctic Test Teams and other U. S. and Canadian groups working at Fort Churchill, Manitoba, Canada, were contacted, and information secured concerning men whose work involved exposure to low temperatures and severe windchill conditions with little opportunity to protect themselves. Men doing these jobs were given an opportunity to try out the masks while working. Each individual was encouraged to try out both types of masks, but was not forced to do so. After a few days the men were again contacted, asked how they were getting along with the masks, and, if required, adjustments and repairs were made. The most common adjustment was to modify the Wood-Hafferty mask for men wearing glasses. This usually involved cutting away a portion of the nose-piece of the mask which pushed against the lenses, and making a space for the temples of the glasses at the sides of the mask, directly in front of the ears. In addition, any seams that had opened or plastic parts that had torn loose were firmly cemented back in their proper positions.

After sufficient time and sufficiently severe weather had elapsed for the users to secure realistic experience with the masks, they were again contacted. Planned interviews were based on previously selected and carefully stated specific and open-ended questions.* Long-hand notations, as nearly verbatim as possible, were taken of the replies. If the individual had used both types of masks, he was asked the same questions concerning each. In many cases the individuals were contacted two or more times, but the complete interview procedure was used only once with each individual for each mask worn. The Quartermaster Bivouac Test Subjects were not available for a sufficiently long

*See Interview Plan in Appendix B.

Figure 1: Wood-Hafferty Mask (front view)

Figure 2: Wood-Hafferty Mask (side view)

Figure 3: Experimental Coldbar Mask, 1955, with pile cap

Figure 4: Experimental Coldbar Mask, 1955, without headgear

time to use the complete set of questions. They were asked fewer questions, but their responses were electronically recorded and transcribed verbatim.

Individuals interviewed were grouped according to the type of work they were doing. Their answers to each question, including spontaneous and volunteered comments, were tabulated separately. The discussion, interpretation, and conclusions which follow are based on study of the tabulated material. The main groups were: 1) equipment operators and men engaged in miscellaneous engineering and surveying activities, 2) gunners and miscellaneous Ordnance personnel, 3) Armor personnel, and 4) Quartermaster test subjects who had been hiking and hauling the gear on sleds during a 3-week bivouac.

5. Value and Limitations of the Data

The total number of men interviewed who were engaged in any one activity was too small to justify a quantitative statistical analysis of the results. However, it is believed that the results from even a small number of men engaged in each of several very different activities are of value and deserve careful consideration by individuals engaged in the development and improvement of devices for protecting the face from extreme cold and wind. The critical comments reported may not be justified in every case, and not all the suggestions for improvement are likely to prove constructive. Nevertheless, the criticisms and suggestions expressed deserve consideration, since they are based on practical experience under realistic conditions. It is probable that criticisms concurred in by all or nearly all the individuals in any one group indicate real faults in a mask for that particular use, and that the majority of the suggestions made point out directions in which improvement is needed.

6. Comments of Wearers Engaged in Engineering Activities

a. Equipment Operators

Five caterpillar tractor and mechanical equipment operators, 3 from U.S. Army Corps of Engineers Field Test Team, Arctic, and 2 from the Royal Canadian Air Force Maintenance Equipment Section, were given the two types of masks to use. Individuals wore the masks from a few hours to as many as 4 or 5 hours a day for 10 days.

Conditions. These men operated large caterpillar tractors which had neither cabs nor windshields. The operator sat on a metal seat on top of the tractor, completely exposed to the cold, wind, and blowing snow, protected only by his clothing. Two of the men spent nearly all day almost every day operating a tractor to pull equipment used in maintaining the airport runways in good condition in spite of the almost constantly drifting snow. The other 3 men operated similar tractors to bulldoze snow, clear roads and storage areas, haul equipment from the base camp to working areas about 10 miles distant, and to do various tasks in the working areas. Four of the 5 tried both

masks, and 1 used only the Wood-Hafferty mask.

All who used them agreed that both masks kept the face warm under windchill conditions as severe as 2200 to 2300 KgCal/m^2/hr, the most severe conditions encountered by these men, except that 3 wearers of the Wood-Hafferty mask complained that the front of the neck and the underside of the chin became cold. This difficulty was overcome by wearing a scarf or turtle neck sweater. The fact that similar complaints were made by men engaged in other activities indicates that the Wood-Hafferty mask fails to protect adequately under the chin.* However, this defect can be eliminated relatively easily during further development. In spite of this defect, all the group judged the Wood-Hafferty mask to be comfortable and to feel good against the skin. In contrast, the 4 users of the Coldbar mask, which fits tightly against the skin, complained that it bothered them, was not comfortable, or made the face sweat. All equipment operators felt that both masks protected their faces from the wind, and some thought that both masks were sometimes too warm.

Work Requirements. The work which these men were doing required good visual acuity and a wide field of vision in order to see the road ahead, to work grades to the height of stakes, to watch the right end of the bulldozer blade to see that it was in the proper position for scraping snow, to look out for planes while working on or crossing the airstrip, and to observe arm and other signals. They also needed to be able to hear sufficiently well to judge, by the sound of the engine, when to shift gears, and to hear aircraft overhead. Ability to smell and possible effects of the masks on this ability were not considered important for this work. There was little need to be able to talk or to understand what others were saying, as it was primarily a solitary job, and the mask's unfavorable effect on the ability to converse was considered unimportant.

All 5 equipment operators liked the Wood-Hafferty mask, and agreed that they would use it all of the time when operating a tractor without a cab under conditions of high windchill. Under the same conditions, the men with experience with the Coldbar mask would also use it if the Wood-Hafferty mask were not available. However, all 4 equipment operators who used both masks greatly preferred the Wood-Hafferty to the Coldbar mask. All wearers of the Wood-Hafferty mask agreed that they could see well enough to do their jobs and that it permitted an adequate field of vision, but one wearer would like to have it tinted to reduce the glare from the sun and snow. One wearer of the Wood-Hafferty mask complained that the bottom of the transparent plastic fogged up after 30 minutes wear. Another found that it sometimes frosted when the wind was from the back. But the other 3 found that it did not frost up when properly worn. Two users found that the mask defrosts

*To avoid unnecessary repetition, comments by other wearers concerning this point will not be given.

itself, especially when the wind is from the side or front.

Although the Coldbar mask has no lenses to frost up, 2 of the 4 wearers found that the eyepieces collect snow, which lodges in the mesh, or blows into the eyes, interfering with visual acuity. Three of the 4 also complained that the field of vision of this mask is too narrow, and that it is almost impossible to wear glasses with it.

The equipment operators found it easy to breathe in either mask, except that on one occasion the bottom of a Wood-Hafferty mask froze full of ice, and had to be cleaned out during an indoor coffee break. This may indicate failure to occasionally remove the ice as it formed, or improper construction of this particular mask.

The Wood-Hafferty mask caused no bother or discomfort except that a little time was required to get used to it. The Coldbar mask was no bother to 2 of the wearers, but one did not like it at all because it became damp and stuck to his face, and another was bothered because it was close to the skin.

Both masks "got in the way" of the equipment operators a little. One wearer of the Wood-Hafferty and 2 wearers of the Coldbar mask mentioned some interference with turning the head, both in response to the questions: "Did the mask ever get in the way?" and "Did the mask make it difficult to turn your head?" Two of the 5 complained that it is difficult to look down in the Wood-Hafferty mask, and 2 of 3 wearers of the Coldbar mask who replied made the same complaint. One wearer of each mask mentioned difficulty in "looking up." Two of the 5 wearers of the Wood-Hafferty mask pointed out that their noses "ran" while wearing the mask, and that it was difficult to wipe the nose, and one of the wearers of the Coldbar mask replied similarly.

None of the wearers of either mask found it necessary to warm the face with the hands while wearing the mask, but wearers of the Coldbar mask thought they could do so if it were necessary. None of the tractor drivers wanted to eat or smoke while operating his equipment, and did not object to the fact that it was impossible to do either while wearing the Wood-Hafferty mask. There were no complaints that either mask interfered with any other activities. Both masks were considered easy to put on and take off, once adjusted to fit the wearer. Both masks were compatible with the pile cap with bill removed, but not with the RCAF cap. All agreed that the Wood-Hafferty mask was compatible with the rest of the clothing. Two wearers of the Coldbar mask felt that the "bib" interfered with turning the head, but one other wearer liked to "zip" the "bib" inside the neck of his parka. All wearers of the Wood-Hafferty mask agreed that it is bulky and will not go in a pocket, but they found that it could be hung on the control lever of the tractor when not in use. However, they all agreed that the Coldbar mask was "handier" and could be folded up and easily carried in a pocket.

In answer to the question, "Does it bother you to have something in front of your face?", 3 of the 5 equipment operators replied they were not bothered. One disliked to look through anything, even a pair of sunglasses, and another disliked anything in actual contact with his face; but the other 3 equipment operators were not bothered.

The qualities most liked about the Wood-Hafferty mask were protection from the wind, warmth, comfort, and freedom from fogging up. The qualities most disliked were that it sometimes fogged up (one wearer), it is impossible to aim a rifle while wearing it, it interferes a little with turning the head, and it needs to be tinted to protect against snow glare.

The Coldbar mask was liked because it kept the face warm, and was easy to carry. However, there were unfavorable comments that the field of vision was too small, glasses could not be worn comfortably with it, and snow stuck in the screen of the eye-pieces, blew into the eyes, and stuck to the face.

Improvements desired in the Wood-Hafferty mask are: more freedom of movement, less fogging, compatibility with aiming and firing a weapon, and tinting to reduce glare. Improvements wanted in the Coldbar mask are a wider field of vision, modifications to make it more compatible with glasses, and means to keep snow out of the eyepieces.

b. Miscellaneous Engineering Activities

Two subjects, an Army sergeant who was a demolition specialist and a civilian expert in core drilling and rock drilling, reported only on the Wood-Hafferty mask.* They wore it while boring holes for explosives with a wagon drill, and while walking through deep snow, "setting stakes," and "shooting in a base line," at temperatures as low as -43 or -44° F with windchills of 2200 $KgCal/m^2/hr$ or more. Both men emphasized the importance of good vision, especially while drilling. The civilian driller, who was 55 years old, wore trifocal glasses. At first, the Wood-Hafferty mask interfered with his glasses, but after minor adjustments were made, this difficulty was practically eliminated. Both men liked the mask, and found that it was comfortable, kept the face warm, and protected it from the wind. Acuity of vision and the field of vision were satisfactory for both men. However, one had to turn his head a little to see while working, and the other suggested the use of tinted material on the inside of the mask as a protection against the glare of the sun on the snow. One found that his mask frosted on the outside when heated up by an exhaust pipe, and the other found that his mask fogged a little, but not badly, when walking downwind. One found that the exhaust of the mask iced up and interfered with his breathing, especially when walking through deep snow,

*The sergeant wore the Coldbar mask too little to express an opinion concerning it, and the civilian was unable to wear it over his glasses.

but he had no difficulty in breaking the ice loose by squeezing the bottom of the mask. The man thought that it was necessary to turn the head a little more with the mask on than when without it and that it was a little more difficult to look down. One had to take the mask off to wipe his nose, but the other found no need to wipe his nose while wearing the mask. Both men liked the mask for use in cold winds and would wear it as much as half of the time in bad weather. One remarked that he did not have to stop work so often to warm his face. The demolition expert liked the mask for standing jobs, but did not like it for the more strenuous activity of walking through snow. The civilian driller liked the protection afforded by the mask, but did not like having to wear it. However, he was of the opinion that equipment operators and foot troops should have such a mask, and suggested that it should be fitted to the wearer's face.

c. Comment by Observer*

A Project Engineer from the Frozen Ground Applied Research Branch of SIPRE, who drove an enclosed vehicle and did not himself need to wear a mask, was in a favorable position to observe the work of the equipment operators and drillers wearing the masks. He noticed that the Wood-Hafferty mask fogged a little, near the bottom. He reported that the men did wear the Wood-Hafferty Mask, in spite of having some trouble with the bright snow and with ice forming in the bottom of the mask, but did not like or wear the Coldbar mask. He pointed out that under some conditions (2360 KgCal/m^2/ hr windchill) men without masks could not face the wind, and consequently worked at only approximately 20% efficiency. He estimated that with a face mask, men could work at 50% to 60% efficiency under similar conditions. As an engineer, he estimated that a face mask would pay for itself in one day in terms of wages saved, lowered overhead, earlier completion of jobs, etc.

7. Comments of Wearers Engaged in Ordnance Activities

a. Gunners

The chief and four gunners of a gun crew from the Ordnance Field Test Team, Arctic, were engaged in activities markedly different from those of the equipment operators or the Engineering Test Team. In the first place, they were much more active physically. They positioned guns, set up and checked test equipment, picked up and carried ammunition, prepared the guns for loading, set fuses, and loaded, aimed and fired.

*This paragraph is based on a conversation with Mr. Robert Benert, a Project Engineer for the Frozen Ground Applied Research Branch of the Snow, Ice and Permafrost Research Establishment, Corps of Engineers, U. S. Army at Fort Churchill, Canada, on 18 February 1956.

These activities involved a good deal of walking through the snow, considerable lifting and carrying, and a little climbing. The visual requirements of this job are different from those of the equipment operator, and probably greater. Gunners must be able to aim the guns with great accuracy, observe the impact and its effect on the target, see any person or vehicle which might get into the line of fire, see small markings to set fuses, and sometimes use a transit to sight the gun. They must be able to hear commands, warnings and signals, and to carry on conversations, both directly and over the phone or radio. While the sense of smell is not critical for this work, it helps to identify explosives, and warns of burning material in the tube of a recoilless rifle which might cause a premature explosion of the next round.

These men had to work in an exposed position, often facing directly into the wind. Members of this group wore the masks from a minimum of 3 days to a maximum of 10 days, in "severe" weather only. The masks were worn from a minimum of 10 or 15 minutes at a time up to a maximum of three hours continuous wear at temperatures as low as -31° F and windchills as high as 2100 to 2380, with blowing snow in the air much of the time.

The four gunners who used the Wood-Hafferty mask found that it worked fairly well but that it fogged up some. One gunner found that it made it a little hard for him to breathe, and that it needed to fit the cap better. The chief of the gun crew, who used the Coldbar mask, said "I find it highly satisfactory." He preferred it to the other mask because he could sight to aim the guns without taking off the mask, and he was unable to do this with the Wood-Hafferty mask. One member of the crew strongly preferred the Wood-Hafferty mask, one had no preference, and the other 2 had limited experience with the Coldbar mask. Three of the 4 gunners who used the Wood-Haffer y mask complained that it fogged up part of the time, and this difficulty continued in spite of attempts at individual fitting and adjustment of the masks.

Both masks were considered to be comfortably warm, but one man who wore both masks judged the Wood-Hafferty mask to be warmer, and another thought it was more comfortable. One gunner complained of cold around the edge of the Wood-Hafferty mask, and the eyelashes of one wearer of the Coldbar mask froze together. Wearers found that both masks satisfactorily protected the face against the wind and felt all right against the skin. Neither mask was ever too warm.

Vision. Gunners found that visual acuity with the Wood-Hafferty mask was satisfactory unless it fogged, and the field of vision was moderately satisfactory. The Wood-Hafferty mask fogged up for one man in 5 to 10 minutes, and in about 1 hour for two other men. It fogged sooner if the bottom of the mask was bumped so that exhaled moisture condensed on the transparent piece, or if the wearer was doing heavy work. The Wood-Hafferty mask did not fog up at all for the 4th man. One wearer of the Coldbar mask disliked the wide space between the eye-openings, and thought it would be better if it opened over the nose. Another Coldbar mask wearer found that ice and snow accumulated

in his goggles and his eyelashes froze together when looking into the wind.

Two users of the Wood-Hafferty mask reported that it interfered some with breathing at first, and later, when exercising strenuously. There were no similar complaints regarding the Coldbar mask. Minor complaints were that the Wood-Hafferty mask interfered with glasses, made the wearer sleepy because the face was warm, and caught the "back blast" from the gun. There was one complaint that the Coldbar mask caused itching above the eyebrows.

Interference with Activities. Two gunners found that the Wood-Hafferty mask got in the way at first, especially when a parka was worn, and interfered with bore sighting and reading the quadrant of the gun. Two other wearers of the Wood-Hafferty mask and the wearers of the Coldbar mask had no such difficulties. One wearer of the Wood-Hafferty mask thought it interfered with turning his head, but other wearers of this mask and wearers of the Coldbar mask did not agree. Some wearers of both masks had a little difficulty in looking down, but wearers of both masks could "look up" as much as necessary. Two of the Wood-Hafferty wearers found that wiping their noses was a problem, but the other did not. Wearers of the Coldbar mask could wipe their noses, but with some difficulty. One thought it would be better if this mask opened over the nose. Inability to warm the face with the hands was not a problem with either mask, since the face did not get cold. One man was bothered by inability to smoke while wearing the Wood-Hafferty mask, and one wearer of the Coldbar mask had difficulty in seeing to light his cigarette, but the other crew members seldom smoked while working. The Wood-Hafferty mask interfered with aiming a gun, getting at an "itch" on the face, and also interfered with firing a rifle. The Coldbar mask did not interfere in any of these ways. There were very minor difficulties in putting on, taking off, and adjusting the masks, especially the Wood-Hafferty. There were slight incompatibilities between cap and mask in the case of both masks; but the Wood-Hafferty did not go with the parka as well as the Coldbar mask did, since it bumped on the parka when one wearer was bending down. When not in use, the Wood-Hafferty mask could be put on the back of the head out of the way, put aside someplace, or hung up in the truck. In contrast, the Coldbar mask could easily be folded up and carried in a pocket. The comments of the gunners in the paragraph above are in close agreement with the comments made by equipment operators in the preceding section.

Summary. Both masks were generally liked, but there were complaints that the Wood-Hafferty mask fogged up and interfered a little with breathing. All the men agreed that most of the time they would wear either mask, or a better one if available, for protection when the windchill is high. Miscellaneous favorable comments about the masks related to protecting the face, keeping it warm, and avoiding frostbite.

The Wood-Hafferty mask was disliked because it interferes

somewhat with glasses and sometimes fogs up, even though it clears in a short time; it takes several minutes to put on and adjust the first time; and it causes some difficulty in breathing. The Coldbar mask was criticized because of the wide opaque space between the eyes, the difficulty of manipulating the closure on the mouthpiece, the wind getting into the eyes and eyepieces, and for poor "glue," which permitted the seams to come apart.

Suggested Changes. The following changes were suggested as desirable in the Wood-Hafferty mask: add flap to fit inside coat and change shape of bottom of respirator to keep it from hitting on the chest. Attach mask to cap, fit the masks individually, and take out baffle plates to make it easier to breathe.

Suggestions for improving the Coldbar mask were to attach a cap to keep the wind from hitting the eyes, decrease the distance between the eyepieces, and substitute a snap closure for the present mouthpiece closure.

b. Engineering Aide and Range Observer

One Engineering Aide (surveyor) working as a Civilian Range Observer used both the Wood-Hafferty and the Coldbar masks to sight impacts with a surveyor's transit, and a second Engineering Aide used only the Coldbar mask to line up and aim guns and to sight impacts. This work required both visual acuity and a good field of vision. Sometimes these men were relatively inactive, and at other times they exercised strenuously when walking through deep snow. It was necessary for them to hear impacts, warnings, instructions, radio and telephone communications, and to carry on shouted conversations at a distance of about 300 feet (the latter could not be done successfully while wearing either mask).

The man who wore both masks used the Wood-Hafferty for half a day at -32° F, with a 14 to 15 mph wind and gusts to 24 mph. He was aiming a gun directly into the wind. In the morning, when he did not wear a mask, his face froze 4 times while he was aiming the gun. In the afternoon he wore the Wood-Hafferty mask, was comfortable, and had no further difficulty from frostbite. He could see satisfactorily unless the mask fogged, but had some difficulty with fogging, especially when he bent down. The mask did not fog on cold-windy days, except sometimes when facing away from the wind, and it cleared easily. He found that the mask interfered slightly with talking, turning the head, and looking down. It was unnecessary to warm his face while wearing the mask. The main difficulty was that he could not get his eye as close to the surveying instrument as he should have liked, and this slowed his work somewhat. Also the mask was clumsy for him to carry when not in use, and the odor of the material smelled up his closet indoors. He liked the mask a good deal, in spite of finding it some bother and inconvenience in front of his face. He liked most the fact that it kept his face warm, and protected it from freezing. He disliked the

fact that the mask sometimes fogs up, he would like to be able to see down better, and he would like to have it made easier to put on and to breathe in.

The same individual also wore the Coldbar mask. He found that it protected his face from the wind and kept it warm, but he felt that it was too tight on his face. Other disadvantages he cited with the Coldbar mask were that it was moist against the skin, and that if he had to take it off and put it on again, "It isn't so good." Vision was considered to be poor, the field of vision was restricted, and one lens of his glasses fogged up. When trying to put the bib of the mask inside his collar he was unable to see to do so, and the bib was bulky and he could not button the collar around it. Other difficulties were that the mask was hard to wear with glasses, and that his lips and chin got cold when the flap of the mask was open. On the other hand, he could smoke while he was wearing the mask, and it was easy to handle and carry when not being worn. However, the main thing he disliked was the fit around the eyes. He had to adjust the eye-pieces to get them in front of his eyes. Also, the mask was hard to fit on the chin, and his glasses fogged up and ice froze on them. He could breathe all right with this mask, but the breath was chillier than when he was wearing the other mask. While wearing this mask he could not see to operate instruments and could not talk satisfactorily.

The second Engineering Aide used only the Coldbar mask. After wearing it one day, he commented: "That was enough; it and I didn't get along." A main difficulty was that it was "just no good" for operating the transit. The eye is too far back, and this resulted in parallax. Also the part of the mask between the eye-pieces is too wide, with the result that he could not focus both eyes on the scale of his instrument. He could see satisfactorily when looking straight ahead, and the screening cut down on the snow glare. However, he could not see his feet or the tripod, he had trouble looking down, the field of vision was too limited for the work, and he fell over some rocks because he could not see where he was walking. His mask did not fog up and snow did not collect in the eye-pieces, but the mask made it a little difficult to breathe, especially when the flap was shut. Also, he had to take off the mask to talk, because the other men could not understand him over the radio, even when the flap of the mask was open. On the other hand, the mask kept his face warm, even when facing into the wind. It was easy to put on, did not interfere with other activities, except as mentioned, it went with the rest of the clothing "OK", and was very easy to handle and carry when not being worn. While wearing the mask, he did not need to warm his face or wipe his nose. However, in spite of the fact that it kept the wind from his face and kept his face warm, he "didn't like it at all," and didn't like it for working. He would not want to use this mask at all, and did not want to try the Wood-Hafferty mask, but thinks that a better mask would be a considerable asset, because all of the impacts are sighted into a northerly wind. The thing he liked most about the mask was that it kept the wind out of his face. However, he did not think that this mask could be changed to suit his particular

job, because better vision is needed, especially for looking down, and it is necessary to call out angles and distances to the man who records them.

8. Comments of Armor Personnel

One Tank Commander, who used the Wood-Hafferty mask at temperatures as low as -62° F and winds as strong as 30 to 40 mph, while stationed at Ladd Field, Alaska, filled out a questionnaire. He wore the mask when his head was outside of the tank, but also sometimes wore it inside the tank. He liked the mask very much,especially for use in windy weather. He found that it kept his face comfortable and warm, protected it from the wind, and did not irritate his skin. While wearing the mask he could hear well, conversations were loud and clear, and ability to smell was fair. He found that the mask did fog up at extremely low temperatures (-40°F to -60°F), but that it could be easily cleared. While wearing the mask, he could not wipe his nose, he had some difficulty in looking down, and had some trouble in putting the mask on and taking it off when wearing his headset and winter headgear. However, he stated: "This mask was the most adequate head protection that I had while in the Arctic. I am quite pleased with the mask and recommend that it be further tested to get out the minor flaws." He also recommended that a mask be provided for tank commanders.* (The similarity of the reactions to the Wood-Hafferty mask shown by the tank commander and the maintenance equipment and tractor operators is not surprising when one considers the similarity in the degree of exposure of the face to cold winds.) This individual did not comment on the Coldbar mask, since he had no experience with it.

One Communications Chief, Armor, whose duties were to put up and maintain telephone poles and lines, wore the Wood-Hafferty mask. (He wore glasses constantly, and for this reason was unable to use the Coldbar mask.) His job required good vision, especially ability to see to the side when he was laying wire. He also had to be able to hear well, to talk and understand, and to climb telephone poles. He found it difficult to see his feet while wearing the mask and climbing. He wore the mask quite a bit, usually for about one hour at a time, at temperatures down to -28° F and at winchills as high as 2240 in blowing snow. For the most part he used the mask when he was checking wire. This involved walking rapidly through the snow. During ordinary walking neither the mask nor his glasses steamed up, but on one occasion, while climbing a pole, he looked down, hit the bottom of his mask against his chest, and broke the seal against his face, causing his glasses to fog. This left him up the pole, completely unable to see until he was able to get the mask off. He found that the mask kept his face warm, felt good against his skin, protected him from the wind, and furnished satisfactory visual acuity and a satisfactory visual field. However, the mask

*Capt. Cecil W. Muller, Ordnance Corps, Chief of the Field Liaison Branch, Psychology Division, Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, in conversation with the author on 25 Sep 1956 at Natick, Mass., agreed with the Tank Commander that protection against the wind and cold is a problem for tank drivers in the Arctic and that either a face shield or a windshield is needed. He observed that at "Moosehorn" men improvised windshields for their tanks.

made it a little difficult for him to look straight down, and his glasses fogged up when the seal against the face was broken by bumping the bottom of the mask. The mask slowed him down slightly when he was walking fast, but otherwise did not interfere with breathing. The mask bothered him very little, except that he was unable to smoke while wearing it. He did not find it difficult to put on, and it went well with the rest of his clothing. When not using it, he carried it easily, slung over his binocular case. He liked the mask very much, and would wear it approximately 6 hours out of 8 when outdoors in severe weather. He liked the fact that the mask protected his face, that he could breathe easily, and that his glasses usually did not steam up. The main changes he suggested were that the angle at the bottom be changed to keep it from bumping against his parka, a bib added, and a Polaroid lens added to reduce sun glare.

In response to the question, "How much can you do with a mask on a cold day?" he made the following remarks: "You can accomplish more with the mask on. You can stay out at least twice as long with it than without it." He wanted to keep the mask permanently. He also suggested that vehicle drivers in Germany, who have windshields down for camouflage purposes, could also make good use of this mask in winter.

9. Quartermaster Test Subjects

Members of this group were engaged in an Arctic ration study* in which their activities were kept quite constant from day to day. Their routine consisted of preparing breakfast every morning; breaking camp; packing and lashing their tents, sleeping gear, food, supplies, and other equipment, on a sled (total weight approximately 200 pounds); hauling the sled approximately ten miles along a trail, wearing boots or snowshoes (either pulling in pairs or taking turns); making camp; cooking the evening meal; and making preparations for the night. It was during the sled-hauling portion of this routine, on the days of greatest windchill, that the face masks were tried out. In addition to the standard parka hood with fur ruff, face masks, a scarf, and one Canadian balaclava were used. No Coldbar masks were used by this group.

All test subjects were given an opportunity to use the Wood-Hafferty mask if they wished to do so, but it was on a purely voluntary basis. Of the 25 test subjects who were interviewed, 14 did not use any mask or face protection except the parka hood. One test subject used and liked a Canadian balaclava, and another used a scarf around his face and liked it fairly well. Of the 9 men who used the Wood-Hafferty mask, 2 liked it,

*Published under the title "Caloric Intake with Prolonged Work in the Cold," by Buskirk, E. R., T. E. Dee, R. F. Goldman and B. E. Welch. Physiology Branch, EPRD, QM R&E Command, Technical Report EP-58, May 1957.

2 disliked it, and 5 were of the opinion that it offered both advantages and disadvantages.

Of the 2 who liked the Wood-Hafferty mask, 1 used it whenever he felt the need for face protection, and liked it; the other liked the mask, but discarded it because of a "runny nose" which forced him to take it off frequently. Of the 2 who definitely disliked the mask, both said that it fogged up, 1 complained that his neck got cold, and the other thought it was too heavy.

Five men liked some things about the Wood-Hafferty mask and disliked others. They all liked the degree of warmth or protection against the cold and wind afforded by the mask; all but one liked it in general, and one mentioned the wide field of vision which it afforded. However, they all criticized certain details. "Cold air went down the back of my neck when the hood wasn't up"; there was not enough ventilation and it was sometimes too hot; it fogged up and was in the way when not needed. Three thought that the mask interfered with breathing, and two complained that it frosted up.

Suggested Changes. Suggestions with regard to the improvement of the mask were: make the box at the bottom smaller and change its shape, make it easier to breathe in more air, keep it from fogging up, make it lighter, increase the ventilation for the face when working or exercising hard, have it fit the cap better, make it so wind will not blow down back of neck, and modify it so you can blow your nose and smoke.

The fact that few of the men wore the masks when available, that they offered few objections when asked to turn them in, and their comments, all suggest that the Wood-Hafferty mask in its present form is not satisfactory for the foot soldier hauling his gear on a sled and that its disadvantages for this purpose outweigh the warmth and protection from the wind which it affords, unless conditions are extremely severe.

10. General Discussion

Results of the literature survey, consultation with men with extensive Arctic experience, and the present study support the view that there is a need for some degree of face protection when the windchill is above 1400 $KgCal/m^2/hr$, the point at which exposed flesh freezes; that there is a definite need for a face mask to protect against cold winds and blowing snow; and that both the need for protection and the acceptability of face masks increase at higher windchills, particularly for men who are inactive physically. However, men prefer not to use a mask unless it is really necessary for comfort or protection. Above a windchill of 2,000 $KgCal/m^2/hr$, face masks are frequently used when available.

The Coldbar mask, which does not lose its insulation value when

wet, is superior to previously developed permeable and impermeable masks which are in direct contact with the skin. However, it is inferior to both the standard dry-cold headgear and the Wood-Hafferty mask in keeping the face warm, and is far inferior to the Wood-Hafferty mask in the field of vision and clarity of vision afforded. In one Quartermaster experiment (32, p. 2), cold air entered the Coldbar mask through the eye-pieces and produced lower skin temperatures (but well within safety limits) at thermocouples located directly above the eyebrows than the Wood-Hafferty mask or the standard dry-cold headgear. Exhaled moisture froze in the small holes in the mouth flaps of the Coldbar mask. This caused difficulty in breathing and also forced exhaled air through the mesh eye pieces, frosting them severely and progressively restricting vision until, at the end of the exposure period, the wearer was completely unable to see. Walking on a treadmill for 30 minutes at $3\frac{1}{2}$ mph did not prevent frosting of the Coldbar mask. Some frosting also took place on the transparent shield of the Wood-Hafferty mask, but the subjects were able to see fairly well because only part of the large transparent area frosted. When the parka hood with the fur ruff was adjusted to keep the subject's face warm, it permitted only a very small field of vision.

In most respects other than size and weight, the Wood-Hafferty mask is superior to masks which are in direct contact with the skin. It shares the Arctic face shield's advantages of good vision and protection from the wind, but keeps the face warmer. It has more air flow around the eyes than other masks with a separate compartment around the eyes and a separate sealed compartment around the nose-mouth area. As a result, it is less apt to fog.

It would have been valuable to compare the Wood-Hafferty mask with the Toque, respirator, but none of the latter device was available. The development of the latter device has perhaps been carried further than that of any other device for protecting the face against cold, except the parka hood with ruff. However, the system of valves in the Toque gave difficulty and the device inclosed the head rather too fully for wear under any except extreme conditions of windchill. It is possible that some of its basic principles could be incorporated into a device for complete head protection; but much additional work remains to be done on this problem.

11. Conclusions

a. Under severe windchill conditions the Wood-Hafferty mask, with minor improvements, would be highly acceptable to, and generally used by, operators of mechanical equipment not furnished with windshields or heated cabs. There is also some evidence that tank commanders have a similar need for face protection, and would also use this mask.

b. Operators of bulldozers and other mechanical equipment prefer the Wood-Hafferty mask to the Coldbar mask.

c. The Wood-Hafferty mask needs improvement in the following

respects for use by equipment operators and other men who are not very active:

1) Stronger construction to prevent leaks around the base of the mask.

2) Better attachment of the head straps.

3) Improved integration with the pile cap or other suitable Arctic headgear.

4) Modifications to make breathing easier, especially at high activity levels.

5) Adjustable ventilation, with maximum ventilation of the upper face increased.

6) Better visibility downward.

7) A color filter to reduce glare, preferably mounted on inside of mask.

8) Greater durability.

9) Elimination of "spotting" caused by condensation of moisture between the two layers of transparent plastic.

d. In addition to 1) through 9) above, the Wood-Hafferty mask, in its present form needs improvement in the following respects for the use of foot soldiers, gunners, and others engaged in a high level of physical activity:

1) Modifications to make it possible to get the eye close to a gunsight, or close to the eyepiece of a transit, telescope, or other optical instrument.

2) Modification (if feasible) to make it possible to eat or smoke without taking off the mask.

3) Modification to decrease interference with breathing, increase air flow through heat exchanger, and make it easier to eliminate ice from heat exchanger.

4) Change in shape of lower part of mask, reduction in its weight, and softer construction, so that it will not hit on chest of parka and break seal of mask against face, causing fogging.

e. The Coldbar mask, which does not lose its insulation value when wet, appears to be superior to previously developed masks which are in direct contact with the skin of the face.

f. The Coldbar mask requires modifications in the following areas:

1) The basic concept of the Coldbar mask is somewhat faulty, in that the direct contact of the mask with the skin becomes uncomfortable and is disliked by most wearers.

2) The field of vision is seriously restricted:

It is very difficult to look down, making walking on rough terrain dangerous.

The field of vision is much too narrow.

The overlap between the fields of vision of the two eyes is inadequate, especially for near vision, making it difficult to read maps, printing, or instruments.

3) The closure for the flap over the mouth is difficult to manipulate and lacks durability.

4) The use of mesh eye-pieces is not satisfactory, because they do not adequately protect the eyes from the wind, snow catches in them, and the breath freezes in them.

g. Under windchill conditions sufficiently severe to require face protection, there is some evidence that the increase in the amount of work accomplished by men wearing masks, as compared with the same men under the same conditions, but without the masks, would in itself be sufficient to justify the development of highly satisfactory face protection against the cold.

h. Desirable Characteristics of a mask.

The following characteristics are desirable in a cold-weather face mask. However, it may not be feasible to build one mask which incorporates <u>all</u> of these characteristics:

1) Must furnish adequate protection from cold, wind, and blowing snow.

2) Should furnish a field of vision which will approach that of a bare-headed individual without a face mask.

3) Must have good optical properties, and should provide for reducing glare when necessary.

4) Must be compatible with cold-weather clothing ensemble.

5) Must offer negligible interference with ability to breathe.

6) Must be compatible with firing weapon.

7) Must be light in weight.

8) Should be easy to carry when not in use.

9) Should permit eating and smoking without removal of mask.

10) Should be inexpensive enough to be made available to all troops exposed to severe windchills, and if possible should be a semi-disposable or disposable item.

11) Must seal off the mouth and nose area from eye area, to prevent fogging of glasses and transparent portion of mask.

12) Should permit control of ventilation of upper and lower parts of face.

13) Must be flexible and manipulatable enough to fit men with faces of various shapes.

14) Should be satisfactory for use by men who wear glasses constantly.

15) Should be compatible with ballistic head protection devices.

16) Should be compatible with gas-protective devices.

17) Should be compatible with ballistic protection for the eyes.

12. Recommendations

a. That research and development of cold weather face masks be continued and expedited in three directions:

1) Development of a mask for equipment operators and others exposed to severe windchill and blowing snow while engaged in a relatively low level of physical activity.. For this mask, comfort and durability would be more important than light weight and small bulk, although obviously the latter should be kept to the minimum compatible with an effective item.

2) Development of a small, light, flexible, easily carried mask for occasional or emergency use by foot soldiers or other men who often engage in high levels of physical activity, and are sometimes subjected to severe windchill conditions.

3) Initiation of long-term plans for the development of complete face protection against unfavorable environmental conditions, CBR warfare,

and fragmentation should take into consideration information secured in studies of the Toque, Respirator, and in this report.

b. That an improved version of the Wood-Hafferty mask be developed and procured in sufficient numbers for issue to operators of open equipment, tank commanders, members of Arctic test teams desiring such protection, and others who are exposed to severe windchill while not engaged in strenuous physical activity. This would be one approach to a1) above.

c. That an improved version of the Coldbar face mask be developed and issued to gunners of the Ordnance Arctic Test Team at Fort Churchill and to troops and civilians engaged in strenuous physical activities under conditions of extreme windchill. This would be one approach under a2) above.

d. That a feasibility study be made of a small, durable, light, easily carried, inexpensive, and disposable face mask for emergency use under extreme conditions. This would be a second approach under a2) above.

13. Acknowledgements

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14. References

1. Anonymous, Report on conference on heat regenerating respirator, OQMG, Rm 2030, "A" Bldg, Washington, D.C., 21 June 1948. (4 pp. "Ditto")

2. Alderson, Samuel W. Research on radical improvement in hand function and head protection, under Quartermaster Contract No. DA44-109-qm-1497. Alderson Research Associates, New York, 13 September 1954.

3. Army Times, New face shield designed for protection in Arctic, 17:17, p. 1, December 1956.

4. Christensen, W. R., Capt., MC. Heat regenerating respirator — protection of respiratory tract in extreme cold. Development, and testing of same. Report No. 53 (originally No. 47), QM Climatic Research

Laboratory, Army Service Forces, Lawrence, Mass., 1 December 1944. (27 pp, 5 tables, and 13 figures).

5. Christensen, W. R., Capt., MC, M. Clinton, Jr., Capt., MC, and R. O. Morris, 2nd Lt., QMC. Pile clothing, experimental, comparative study of thermal insulation, Report No. 57-VII CRL. Quartermaster Climatic Research Laboratory, Lawrence, Mass., 29 April 1944 (28 pp. and 1 figure).

6. Christensen, W. R., Capt., MC, J. C. Cooper and R. Silver. Goggle, M-1944. Experimental studies on moisture absorbing lens. Report 82 (R121A), Army Service Forces, Quartermaster Climatic Research Laboratory, Lawrence, Mass., 27 December 1945. (14 pp. and 2 figures)

7. Christensen, W. R., Capt., MC, and C. E. Cross, T/4. Goggle, cold weather, non-fogging, experimental, incomplete inner lens. Provisional report, goggle project, Quartermaster Climatic Research Laboratory, Lawrence, Mass., 27 September 1944. (pp. 387-388)

8. Christensen, W. R., Capt., MC, and C. E. Cross, T/4. Goggle, cold weather, non-fogging, experimental, condenser type. Provisional Report, Test No. R-121-44, Quartermaster Climatic Research Laboratory, Lawrence, Mass., November 1944. (12.pp. including 5 figures)

9. Christensen, W. R., Capt., MC, Cross, Nelson, and Emerson. Mask, face, cold weather, modified for non-fogging goggle. Provisional Report, 27 November 1944, Test No. R-121-44. (1 p. and 1 figure)

10. Christensen, W. R., Capt., MC, C. E. Cross, T/4, Cpl. Skalkeos, and Pvt. Landry. Goggles, anti-fog, use of gelatin-coated films. Provisional Report, Quartermaster Climatic Research Laboratory, 3 November 1944, Lawrence, Mass. (3 pp.)

11. Christensen, W. R., Capt., MC, and A. M. Galligan. Mask, field, pile, experimental. Report No. 48 (113), Quartermaster Climatic Research Laboratory, Lawrence, Mass., 20 October 1944. (28 pp. and 5 figures)

12. Christensen, W. R., Capt., MC, and Lt. Morris. Heat regenerating respirator units and face masks for same. Provisional Report, Test No. 47. Quartermaster Climatic Research Laboratory, Lawrence, Mass., 25 April 1944. (pp. 120-125)

13. Cowan, C. R., Development of goggles for wind protection. Royal Canadian Navy, Defence Research Board, Ottawa, Canada. Fourth Commonwealth Conference on Clothing and General Stores, London, England, 1953. (6 pp, plus Appendix A (1 p., 3 figs.), and Appendix B (2 pp.))

14. Cross, Chester E., T/Sgt. Goggles, cold weather, non-frosting, ventilated, double lens, and condenser type. A register of

experimental models. Report No. 105 (originally R-121-44). Quartermaster Climatic Research Laboratory, Research & Development Branch, Military Planning Division, Office of The Quartermaster General, Lawrence, Mass., 9 August 1946. (56 pp. and 43 figs.)

15. Dougherty, W. L., 1st Lt., QMC. Task Force "FROST," Military Planning Division, Office of The Quartermaster General, Washington, D.C. Not dated. (29 pp. plus 20 pp. of unnumbered photographs, two photographs to a page)

16. Gaydos, Henry F. Human engineering evaluation of the Wood-Hafferty cold weather face mask. Environmental Protection Research Division, Research Study Report PB-6. U. S. Army Quartermaster Research and Development Center, Natick, Mass., July 1956. (10 pp.)

17. Goddard, W. L. and T. E. Dee, Jr., Toque, respirator, EX-49-2. Quartermaster Climatic Research Laboratory, Lawrence, Mass., 29 September 1950. (Typewritten - 8 pp.)

18. National Research Council. Principles of protection applicable in extreme cold. Committee on Quartermaster Problems, Subcommittee on Environmental Protection, Minutes of 11 and 12 May 1948 Meeting of Working Group and Guests. Quartermaster Climatic Research Laboratory, Lawrence, Mass., dated 29 June 1948. (10 pp.; Appendix A, 7 pp.; Appendix B, 3 pp.).

19. Orr, K. D., Lt. Col., MC, and D. C. Fainer, Capt., MC. Cold injuries in Korea during winter of 1950-51. Army Medical Research Laboratory, Fort Knox, Ky., November 1951.

20. Palmes, E. D., H. F. Frazer, and M. E. Smith. A new general purpose face mask for protecting military personnel at low ambient temperatures, with special design to prevent frosting of goggles. Protective Clothing Report No. 27, Industrial Hygiene Research Laboratory, National Institute of Health, U. S. Public Health Service, Bethesda, Maryland. Not dated (probably 1944).

21. Palmes, E. D., H. F. Frazer, and M. E. Smith. A face mask and goggle combination utilizing new principles to reduce fogging and frosting. Protective Clothing Report Number 28, Industrial Hygiene Research Laboratory, National Institute of Health, U. S. Public Health Service, Bethesda, Maryland (Nov. 1944).

22. Polaroid Corporation, Research Department. Report prepared by Chubb, L. W., Jr. Low temperature face protective device, Interim Report No. 1, Period June 1, 1948 to July 31, 1948. Quartermaster Corps, U. S. Army, Contract No. W44-109-qm-2031, Cambridge, Mass., (10 pp., 4 figs., and 1 appendix, 3 pp.).

23. Polaroid Corporation, Research Dept. Low temperature face protection device, Interim Report No. 2, period August 1, 1948 to September 30, 1948, under Quartermaster Corps, U. S. Army, Contract No. W44-109-qm-2031. Cambridge, Mass. (18 pp, 8 pp. of tables, and 1 photograph).

24. Polaroid Corporation, Research Dept. Report by Chubb, L. W., Jr. Low temperature face protective device, Interim Report No. 3, period October 1, 1948 to November 30, 1948, under Quartermaster Corps, U. S. Army, Contract No. W44-109-qm-2031. Cambridge, Mass. (23 pp., and data sheets ix through xxi)

25. Polaroid Corporation, Research Dept. Low temperature face protective device, Interim Report No. 4, period December 1, 1948 to January 31, 1949, under Quartermaster Corps, U. S. Army, Contract No. W44-109-qm-2031. Cambridge, Mass. (11 pp. and 5 figs.)

26. Polaroid Corporation, Research Dept. Low temperature protective device. Interim Report No. 5, period February 1, 1949 to March 31, 1949, under Quartermaster Corps, U. S. Army, Contract No. W44-109-qm-2031. Cambridge, Mass. (12 pp.)

27. Polaroid Corporation, Research Dept. Report prepared by Chubb, L. W., Jr. Low temperature face protective device. Interim Report No. 6, period April 1, 1949 to June 30, 1949, under Quartermaster Corps, U. S. Army, Contract No. W44-109-qm-2031. Cambridge, Mass. (14 pp.)

28. Polaroid Corporation, Research Dept. Report prepared by Chubb, L. W., Jr. Low temperature face protective device. Interim Report No. 7, period July 1, 1949 to September 30, 1949, under Quartermaster Corps, U. S. Army, Contract No. W44-109-qm-2031. Cambridge, Mass. (14 pp. and 12 figs.)

29. Polaroid Corporation, Research Dept. Report prepared by Chubb, L. W., Jr. Low temperature face protective device. Interim Report No. 8, period October 1, 1949 to December 31, 1949, under Quartermaster Corps., U. S. Army, Contract No. W44-109-qm-2031. Cambridge, Mass. (19 pp. and 5 figs.)

30. Polaroid Corporation, Research Dept. Report prepared by Chubb, L. W., Jr. Low temperature face protective device. Final Report, January 1951, under Quartermaster Corps, U. S. Army, Contract No. W44-109-qm-2031. Cambridge, Mass., January 1951. (15 pp., 8 figs., plus appendix, 5 pp., 2 figs.)

31. Price, A. Preliminary report of observations of standard and experimental cold weather clothing and related items under Antarctic conditions. Operation DEEPFREEZE I, period December 1955 to March 1956. R&D Report No. 14, Clothing Supply Office, U. S. Naval Supply Activities, N.Y., (Busanda Reports Control Symbol 3950-2) Brooklyn, N.Y. (pp. 1-17)

32. Roush, O. W. Technical information on Arctic face masks. Letter report on Chamber Study 11A56,5606, QM R&D Command, Natick, Mass., 7 Feb 57. (4 pp.)

33. Sapin-Jaloustre, Dr. J. Le problem de la vision dans le blizzard. Annales d'optique oculaire, Volume 3, No. 2, pp. 36-53, 1954.

34. Shanahan, L. W. Test of experimental Arctic face shield, Fort Churchill, Canada, Winter 1947-48. Report 1104, Engineer R&D Laboratories, The Engineer Center, U. S. Army, Project 8-98-07-001, Fort Belvoir, Va., 4 March 1949. (10 pp.)

35. Shanty, F. A thermodynamic study of lens fogging in protective masks, CRLR 149, Project 4-80-02-006, Chemical Corps Chemical and Radiological Laboratories, Army Chemical Center, Maryland, 23 June 1953. (pp. vi and 39).

36. Siple, Paul A. Clothing and climate — Chapter 12 in Physiology of Heat Regulation and Science of Clothing. Newburgh, L. H., Editor. W. B. Saunders, Philadelphia, 1949. (pp. vi and 457).

37. Slauta, Michael and T. Bouse, 1st Lt., QMC. Task Force "FRIGID." Military Planning Division, U. S. Army, Office of The Quartermaster General, Washington, D. C. Not dated. (probably March 1947). (46 pp.)

38. Stefansson, Vilhjalmur. Arctic Manual. Macmillan, New York, 1945 (556 pp).

39. Stefansson, Vilhjalmur. My Life with the Eskimo. Macmillan, New York, 1949. (p. 538).

40. Treiber, Kenneth L. (Alexandria, Va.) Face Shield. Patent 2,758,307, issued by U. S. Patent Office, 14 August 1956.

41. U. S. Army Air Forces Board, Report of: Weather mask — requirements for use of AAF Personnel, Project No. (m-4)491. Orlando, Florida, 26 April 1944. (5 pp and 5 incls).

42. U. S. Army Field Forces Arctic Test Branch. Report of Test — Arctic Test of Toque, Respirator, EX 51-5, Big Delta, Alaska, 13 June 1953. (3 pp. and 4 appendices: A - 7 pp; B - 3 pp; C - 1 p; D - 1 p.)

43. U. S. Army Field Forces Board No. 3. Report of Test of Project No. 2193 (W/T) headgear. Fort Benning, Ga., 14 October 1949. (pp. 1-43).

44. U. S. Army Field Forces Board No. 3. Letter to Office of Chief of Army Field Forces, Fort Monroe, Va. Tentative Report of Project No. 2554, (ATB) Arctic test of toque, respirator, EX-51-5 (DA Project 7-80-08-001). Fort Benning, Ga., 24 July 1953. (2 pp. and 1 inclosure).

45. U. S. Army, Office of The Quartermaster General, Military Planning Division, Research and Development Branch. Summary of Reports, Winter 1946-47 on Arctic Field Trials. QM Textiles, Clothing and Footwear, FRIGID, WILLIWAW, and FROST. Washington, D. C., April 1947. (415 pp.).

46. U. S. Army, Office of The Quartermaster General, Military Planning Division, Washington, D. C. TASK FORCE WILLIWAW. Not dated. (78 pp. and Appendices A through N).

47. U. S. Army, Quartermaster Board. Technical Report Test of Mask, EX-49-2, QMB T-4968. Fort Lee, Virginia, 12 May 1950. (2 pp. plus 2 pp. of inclosures).

48. U. S. Army, Quartermaster Board. Technical Report QMBT - 1067-51105. Toque, respirator EX 51-5. Fort Lee, Virginia, 1952. (14 pp., including a 4-page appendix).

49. U. S. Army, Quartermaster Climatic Research Laboratory Report. Quartermaster Equipment on Harvard Mountaineering Club — Mt. St. Elias Expedition. Lawrence, Mass., 27 Nov 1946. (31 pp., 2 tables and 7 figures)

50. U. S. Army, Navy, Air Force, and Munitions Board Standards Agency. Index of specifications and standards (used by) Department of the Army, Military Index, Vol. II, dated 2 April 1956. U. S. Government Printing Office, Washington, D. C., 1956.

51. U. S. Army, Navy, and Air Force Military Specification MIL-H-17024A, 10 July 1952, superseding MIL-S-17024 (S & A), 15 January 1952. Hood, Cold Weather (Shore) A-1. U. S. Government Printing Office, Washington, D. C. (8 pp., illus.)

52. U. S. Army, Navy, and Air Force Military Specification MIL-H-11023B(1), 22 April 1953, superseding MIL-H-11023A(QMC), 1 August 1952, Hood, Parka, M-1951. U. S. Government Printing Office, Washington, D. C., 1953, plus Amendment 1, 29 June 1954 (same no.). (16 pp., illus.)

53. U. S. Army, Navy, and Air Force Military Specification MIL-M-3704, 21 February 1952, and Amendment 1, 21 May 1953, Mask, Cheek Protector, Arctic. U. S. Government Printing Office, Washington, D.C. 1953.

54. U. S. Army, Navy, and Air Force Military Specification MIL-M-7475A, 16 February 1953, superseding MIL-M-7475 (USAF) 13 March 1952, Mask, Cold weather, Type D-1A. U. S. Government Printing Office, Washington, D. C., 1953. (8 pp, including four figures).

55. U. S. Naval Supply Activities, New York: Shipboard evaluation of experimental cold weather clothing (aircraft carrier phase). Report No. 3, R&D Division, Clothing Supply Office, Brooklyn, N. Y. 1955. (19 pp, 12 plates and 2 p. appendix). (BUSANDA Reports Control Symbol 3950-2.)

56. Wilkins, Sir Hubert and A.L.Lastnik. Disclosure of invention (a form-fitting protective face mask for use in the Arctic). To Charles C. Rainey, Patent Advisor, QM R&D Command, Natick, Mass., 19 Sep 1955.

57. Wilson, L. G. Protection of the face in regions of high windchill. Defence Research Chemical Laboratories, Protective Equipment Development Section, Note No. 111. Ottawa, Canada, January 12, 1950. (2 pp and 1 page photograph).

58. Wood, E. E., and W. A. Hafferty. U. S. Patent 2,665,686.

Figure 5: Army: Parka Hood with Fur Ruff, M-1951 (closed against the wind)

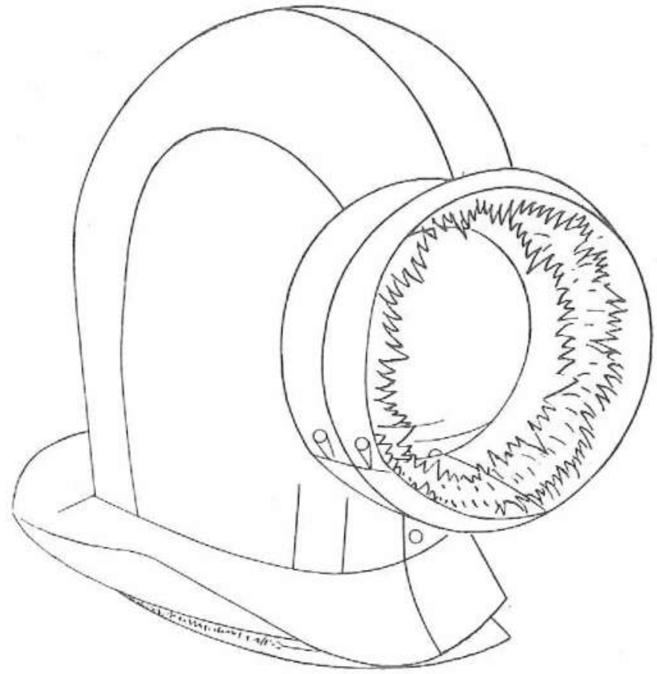

Figure 6: Navy: Hood, Cold Weather, (Shore) A-1

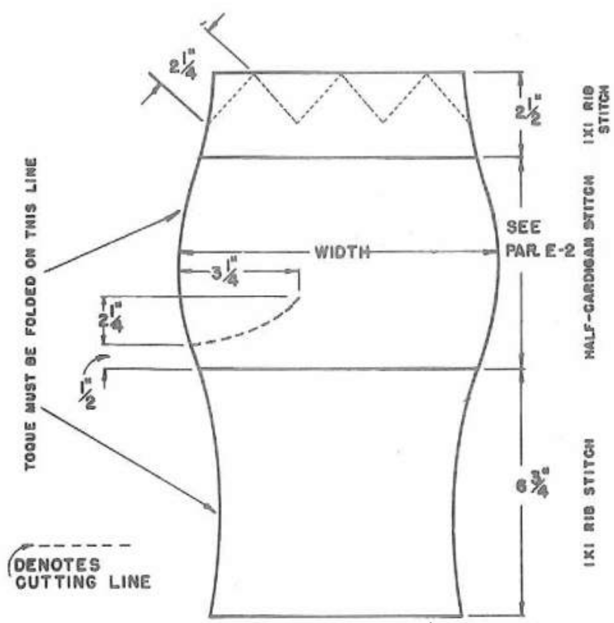

Figure 7: Wool Knit Toque, M-1941 (side view)

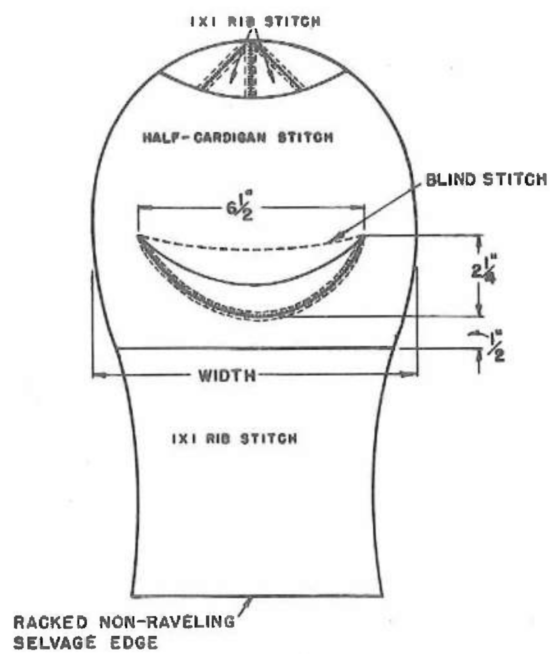

Figure 8: Wool Knit Toque, M-1941 (front view)

Figure 9: QM Standard Mask, Face, Wool Felt, Type D-1 (M-73-1000 OD) (M-73-990 Blue)

Figure 10: Mask, Chamois, 653

Figure 11: Mask, Navy, 651

Figure 12: Mask, Field, Experimental, Double-faced wool pile

Figure 13: Mask, Cheek Protector, Arctic (showing frost formation)

Figure 14: Chemical Corps Experimental Positive Pressure Face Mask as constructed by Polaroid

Figure 15: Arctic face shield and mask, modified by Polaroid Corp.

Figure 16: Lensless goggles (Cowan)

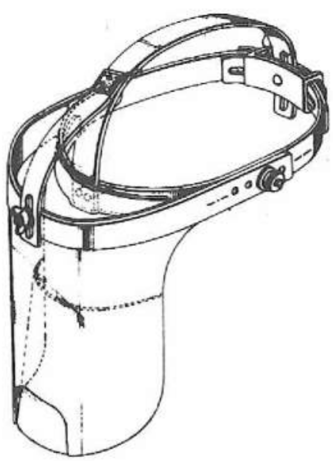

Figure 17: Arctic Face Shield, Corps of Engineers

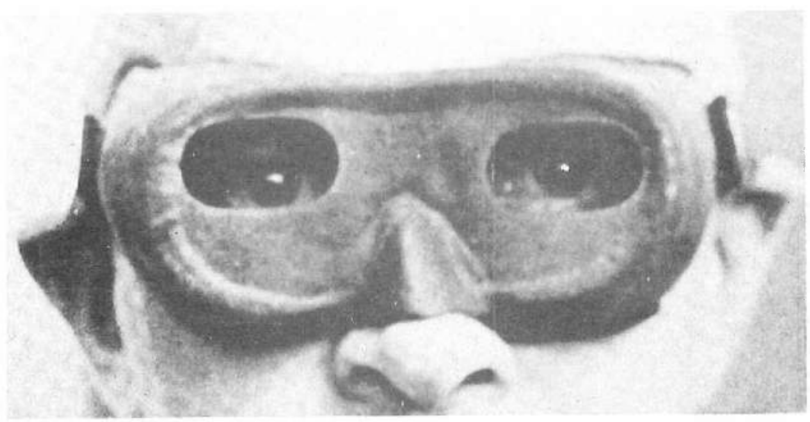

Figure 18: Lensless goggles (Cowan)

Figure 19: Toque, Respirator
EX 50-3

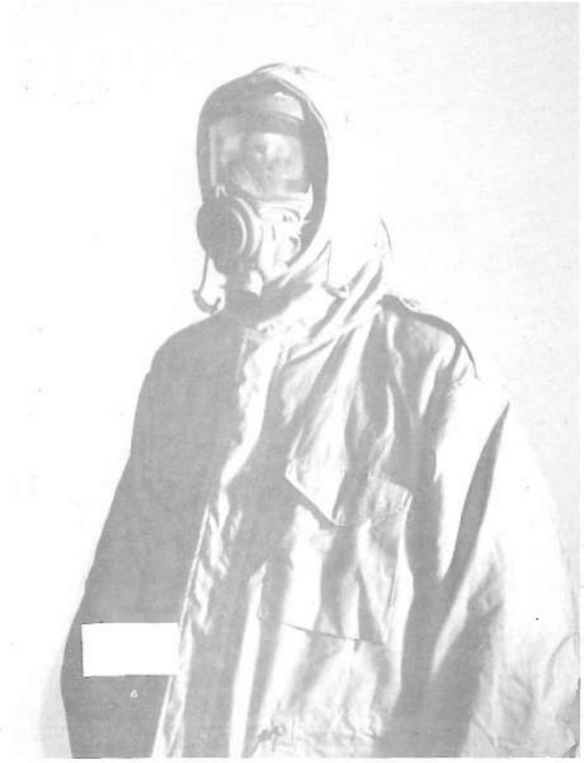

Figure 20: Toque, Respirator
EX 50-3

Figure 21: Toque, Respirator
EX 50-3

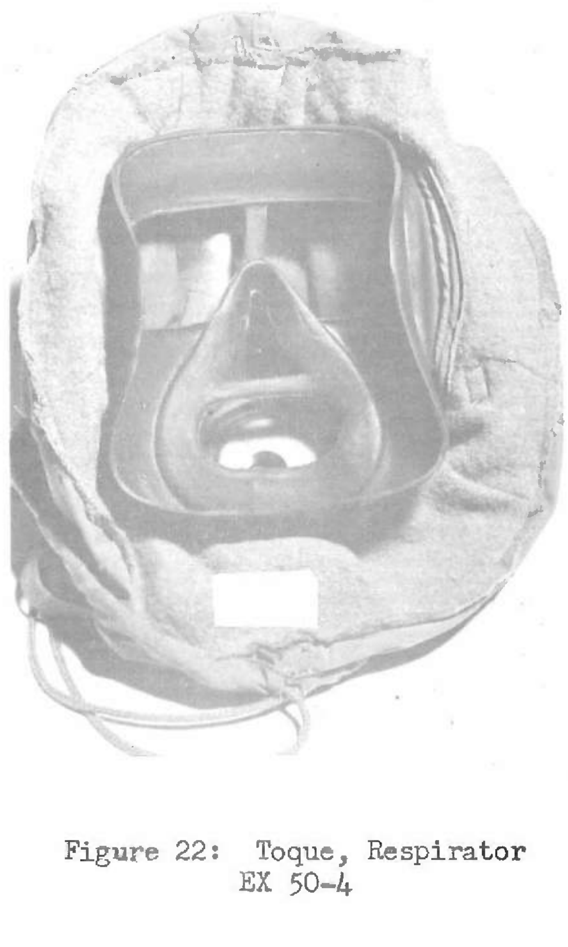

Figure 22: Toque, Respirator
EX 50-4

APPENDIX B - Interview Plan*

1. What is your:
   - Name?
   - Age?
   - Rank?
   - Organization?

2. What is the MOS or name of your job?
   - Describe the work you do in one or two sentences.
   - Give a brief specific description of the types of activity involved in your job.
     - How much activity is involved?
     - What kinds of movements are involved?

3. What are the sensory requirements of your job?
   - How well do you need to be able to see to do your job?
     - Acuity of vision required?
     - Field of vision required?
   - Do you wear glasses on the job?
   - How well do you need to be able to hear?
   - How well do you need to be able to smell?

4. How important is it for you to talk and understand while working?

5. What other requirements are there for your job?

6. How much did you wear the mask?

7. Under what conditions did you wear it?
   - Usual temperature?
   - Minimum temperature?
   - Usual windchill?
   - Maximum windchill?
   - How much did you wear the mask?
   - How long did you wear it at any one time without a break?
   - Did you wear it during snowfall or other special conditions?

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*The Interview Plan outline was used with each man to secure information concerning the effectiveness of each cold weather face mask worn. However, an effort was made to keep the interviews as natural and flexible as possible. Interviewees were encouraged to talk freely as long as their comments were relevant, and notes were taken of the information furnished. The wording of the questions in the Interview Plan was followed closely, but questions were omitted if the information had already been furnished. Supplementary questions were occasionally asked when required to secure a clear and unambiguous answer.

8. What were you doing while wearing the mask?

9. How well did the mask work?

10. Was the mask comfortable, or not?

11. Did it keep your face warm?

12. Did any part of your face get too cold?

13. How did the mask feel against your skin?

14. Did it protect your face from the wind?

15. Was it ever too warm? (under what conditions?)

16. How well could you see while wearing it?
    Visual acuity:
    Field of vision:

17. Did the mask fog or frost up? (under what conditions?)

18. Did the mask make any difference in breathing?
    Easier or more difficult?
    How much effect?
    Under what conditions?

19. Did the mask bother you, or cause discomfort in any way?

20. Did the mask ever get in the way?

21. Did the mask make it difficult to:
    Turn your head?
    Look down?
    Look up?
    Wipe your nose?
    Warm your face with your hands?
    Smoke?
    Eat?

22. Did the mask interfere with any other activities?

23. How easy was it to put on, take off, adjust, etc.?

24. How did it go with your headgear?

25. How did it go with the rest of your clothing?

26. Was it easy to handle and carry when not being worn?

27. Did your chin or neck get cold?

28. How well do you like the mask?

29. How much would you wear this mask here at Fort Churchill if you had one to keep?

30. How much would you wear a better mask if you had one?

31 Does it bother you to have something in front of your face?

32. What did you like most about the mask?

33. What did you dislike about the mask?

34. What changes would you like to see made in the mask?